Influence of the track geometry variability on the train behavior

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At its building, the theoretical new railway line is supposed to be made of perfect straight lines and curves. This track geometry is however gradually damaged and regularly subjected to maintenance operations. The appearing irregularities are thus characterized by a short wavelength description (between 3 and 100 meters) whereas the geometry of new tracks is characterized by long wavelengths. These irregularities are of four types: vertical and horizontal alignment irregularities on the one hand, gauge and cross level irregularities on the other hand. In this work, a parameterization that suits this double scale representation is thus proposed. Each rail position is characterized by a mean position, which only depends on the track design and a deviation towards this mean value, which only depends on the irregularities. Since the mean line description is chosen at the building of a new railway line for economical and political reasons, this work only focuses on the track irregularity vector gathering the four track irregularities. This double scale description is illustrated in Figure 1. The appearing irregularities may be different from one track to another one, from one country to another one, depending on the physical properties of the track substructures, on the traff c conditions (number, type of trains) and on the geographical locations (which can be correlated with weather conditions). Hence, during its lifecycle, the train is bound to run on a great variability of track conditions.

As the track / vehicle system is strongly non linear, the dynamic behaviour of the trains, which is mainly induced by the track geometry, has therefore to be analyzed not only on a few track portions but on this whole realm of possibilities. It is however diff cult to simulate runs on the whole railway network as well as to f nd portions of track that are representative of the whole network. This work is thus devoted to the development of a stochastic modeling of the track geometry and its identif cation with experimental measurements. This modeling, which has to integrate the statistical and spatial variabilities

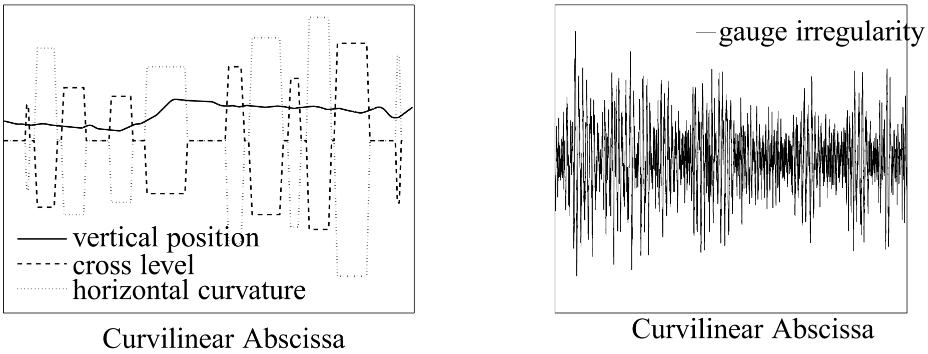

Figure 1: Long wavelengths desciption (left), short wavelengths description (right).

and dependencies, is a key issue when using simulation for conception, maintenance or certif cation purposes.

To model this variability, a local-global approach is f rst proposed; this means that a whole track of length S_{tot} is considered as the concatenation of N track portions of same length S. Each portion is then supposed to be one realization of the same stochastic process $\boldsymbol{X}$, for which statistical properties have to be identif ed from experimental track measurements.

The f rst step of the modeling is therefore to f nd the optimal local-global length S, which allows taking into account the maximum information of the track irregularities. From a set of track portions of same properties, the correlation matrix of stochastic process $\boldsymbol{X}$ can then be computed. According to the Karhunen-Love expansion theory (see [1]), the irregularity vector is projected on a deterministic orthonormal basis. At last, the projection coeff cients, which are random values, are expanded on a Polynomial Chaos basis (see [2]).

Finally, the track stochastic model allows generating railway tracks that are representative of a whole network, realistic, and can be used in any deterministic railway dynamic software to characterize the dynamic behavior of the train.

References

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